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Standard Model | **Homework 3** | **Date: 17.07.2019**

Exercice 1: Two-body decays

Using energy and momentum conservation, show that in a 2-body decay, $A \to B+C$, the energy and momentum of the daughter particles in the rest frame of the mother particle are given by

$$E_B = \frac{m_A^2 + m_B^2 - m_C^2}{2m_A}c^2, \quad E_C = \frac{m_A^2 + m_C^2 - m_B^2}{2m_A}c^2$$

$$p = \frac{\sqrt{\lambda(m_A, m_B, m_C)}}{2m_A}c$$

with

$$\lambda(m_A, m_B, m_C) = (m_A + m_B + m_C)(m_A + m_B - m_C)(m_A - m_B + m_C)(m_A - m_B - m_C).$$

Exercice 2: Standard Model: interactions and conservation laws

Are the following decays permitted in the Standard Model? If not, why?

1. $n \to p\mu^-\bar{\nu}_\mu$
2. $\mu^- \to e^-e^-e^+$
3. $n \to p\nu_e\bar{\nu}_e$
4. $p \to e^+\pi^0$
5. $\pi^0 \to \gamma\gamma$
6. $\tau^- \to \mu^-\gamma$
7. $K^0 \to \mu^+e^-$
8. $\mu^- \to \pi^-\nu_\mu$
9. $\mu \to e\gamma$
10. $\mu \to e\nu_e\bar{\nu}_\mu$

Exercice 3: BSM proton decay

With the particle content of the SM, baryon number is an accidental symmetry when restricting to renormalisable interactions. What is the mass dimension of the interactions that can induce a decay of the proton? Given that the current experimental lower bound on the lifetime of the proton in 10^{34} years, find the lower bound on the scale of these interactions.